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ABSTRACT

This paper argues that the advent of the optical videodisc has removed one of movie making's basic tenets: that is, the unfolding of the imagery and the order of succession of the frames. It maintains that the optical videodisc provides the opportunity for topical and temporal reconfiguration of the images wherein the viewer becomes an active participant interfacing with computer programs that serve as intermediaries between the viewer and the film. The paper goes on to explore new types of movies and new film techniques made possible by videodisc technology, and the role of the computer in random access--and interactive--movies and available interfaces for users. Additional technological developments that may provide the user with a "virtual camera" as well as a computer to edit are briefly considered. (Author/MER)

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THE IMPACT OF OPTICAL VIDEODISCS ON FILMMAKING

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June 1979

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THE IMPACT OF OPTICAL VIDEODISCS ON FILMMAKING

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1.0 INTRODUCTION

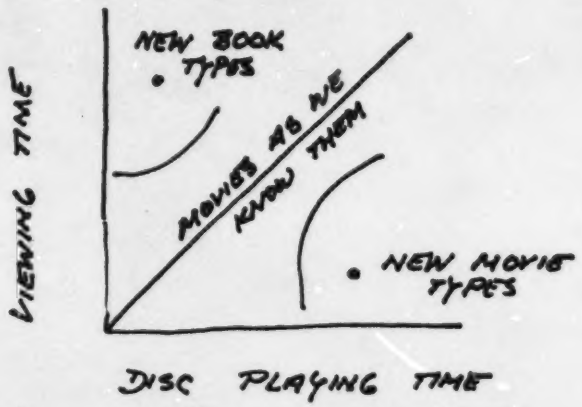
A motion picture is precisely that. The illusion of movement is gained by a rapid and steady sequence of slightly different, but sufficiently similar, still frames. All forms of existing cinema are derived in the making of this sequence, in the camera and at the editing table. This is about to change, as filmmaking passes from a sequential to a random access medium.

The advent of the optical videodisc removes one of the most basic tenets of movie making; that is: that the unfolding of the imagery, that the order of succession of the frames, is established apriori and forever. By contrast, the optical videodisc affords the opportunity for topical and temporal reconfigurations to the extreme extent that a particular "film" is only seen once by one person; that its likelihood of reappearance in that form is zero.

The viewer becomes an active agent and computer programs serve as the intermediaries between that viewer and the film, as described in a database. Thus filmmaking acquires much of the flavor of computer programming, where logical constructs are prepared for unpredictable traversals through an information space. Filmic material can be seen as a vast archipelago of episodes around which one can voyage in a more or less random fashion. Directed passage comes from particular needs, at particular times, in accordance with the idiosyncrasies of a particular viewer.

1.1 Screenplay versus Publication

At the onset it is important to recognize the dual nature of this new medium, as a surrogate book as well as a new film form. The naturally evolved term "videodisc" is somewhat misleading by its direct association with television, hence movies. One of the most important applications of this new technology will be as a publishing medium for illustrated, written and spoken material, emphasizing the still frame. The following graph is one characterization of the difference:



The distinction will become thin as soon as we envisage "books" whose photographs are movies and whose diagrams are animated, or as we imbed more and more still frame material into "movies." But, for the time being, in the early evolution of this medium, the difference is important to information realestate and computer modeling. To model the contents of 54,000 different images (the number of frames in a half hour of video) is an herculean task. Similarly, a truly interactive movie can only be achieved with significant increases in realestate, well beyond the current limitations of a half or full hour of material per side of a disc.

The focus of this paper does not include aspects of "Books without

Pages," but is confined to the consequences to filmmaking, with the overt agenda of stimulating change in the practice and teaching of film. A new breed of artist is needed. In the meantime, we will inevitably suffer through clumsy adaptations and mindless recycling and reselling of old movie material.

1.2 New Audiences

Consider the audience of and for one. Oneness comes in three ways: only one viewer might be looking at the screen, the content is delivered as a result of one specific need, and the delivery is in one specific form that reflects the viewer's previous experiences and cognitive style. In a limiting case, the same presentation to another observer might appear like gobbledegook.

New audiences will also come from the formal and informal education markets, where audiovisual material has played only a minor role to date. Combined with emerging techniques for computer aided instruction and a growing presence of computers in the home, one can expect to learn the geography of Gotland by going there, to diagnose diabetes by doing it, practice paddle by playing it.

Finally, there is the important audience too proud to stoop to the common denominator of intellectual appeal forced by the limited resource of bandwidth available to the networks as we know them. What you might call the book-reading audience is a new audience for mass media. And optical videodiscs are a new and important kind of mass media (quite capable of cleansing the word of "media").

1.3 The Technology

Optical videodisc research started at a time when videotape, especially consumer systems, were almost non-existant. The initial motivation was to resell movies.

In the presence of a formidable videotape market, distribution, and consumer understanding, the disc must be re-evaluated, in terms of its intrinsic difference: random access. Other arguments, like the materials costs to manufacture a movie, are secondary issues inasmuch as they can swing in the presence of new inventions and are not fundamental properties. Whereas the geometry of a rotating system in comparison to a linear tape, makes for an inherently non-sequential medium. That is the difference.

Some manufacturers see sufficiently large markets in play-through material to justify the videodisc on that basis alone. Of course this becomes even more true when manufacturing costs of the disc can be so low that videotape is incomparable. One can look upon the justification of the technology in their terms with some fondness, when considering that it will open opportunities for the distribution of high quality material to low density audiences. But then there is no innovation in the medium of the kind that will impact the filmmaking process.

1.3.1 Why optical?

The qualification "optical," rooted in the title of this paper, is meant more to indicate a specific property than to vote for a particular technology. At this time, capacetance, contact and non-contact, and even mechanical systems are vying for a market share, primarily through the venue of play-through material. An

unfortunate outcome would be a quasi-standardization on these non-optical media, without due homage to the still frame.

With the proper continuous angular velocity (1800 RPM is one frame per track, for 30 FPS), today's optical videodisc players can freeze a frame indefinately without wear or deterioration. From an application point of view, this can be likened to leaving a book open to a specific page: to read it, while answering the telephone, over dinner.

The same feature can be achieved if one has a frame grabber. Computer memory will be sufficiently inexpensive to presume solid state frame stores in a few years, capable of emulating the current still frame, achieved by continuous replay of a specific track. In such a case, one can consider technologies which do not lend themselves to endless replay and the qualification of optical becomes less important.

1.3.2 Assumed Feature Set

The following enumeration of features are a postulation of a machine which is not currently available, but exists as disembodied technical achievements in various laboratories and corporations. Throwing together disjoint technical accomplishments serves the purpose of reviewing filmmaking techniques in the light of what will be the most dramatic departure possible from current cinematic media.

Still frame is the most important feature. In addition to its asset as a surrogate page, it is the basis for slow and fast motion, forwards and backwards. Unlike film, frame rates cannot be changed to achieve expansions or contractions in time. Instead, frames must be repeated or skipped, requiring the basic property of a freeze frame feature.

The diagram early on illustrated a viewing time considerably shorter than play time, in applications of the sort of an interactive movie. Today's system range from a half to full hour using various tricks (some of which preclude, alas, still frames). For the time being, let's assume a near future of two to four hours, or between 200,000 and 400,000 frames.

Consider at least two sound tracks and realestate for data (to be discussed later). Current systems have two tracks for sound, used for either stereo or multiple languages. Two is probably insufficient.

Finally, there is the issue of access time, which ranges from five to twenty-five seconds, worst case, first to last track. Some recent developments in data processing applications of optical disc technology has resulted in one tenth of a second worst case. Let's assume a one or two second access time.

1.3.3 A two headed system

In the absence of a filming populace prepared to make interactive movies, it is quite natural to find today's videodiscs incapable of concatenating scenes on the fly. If frames 200 to 1000 are to be followed by frames 3000 to 4000, there will clearly be a blanking period, while the player travels the 2000 frames forward; even a fraction of a second is unsettling.

A two headed system relieves the problem inasmuch as one head is free to scan while the other plays. This can be easily emulated by running two players, which is precisely what we do today. Note, it affords the opportunity to fade into sequences, perform special effects, and the like.

While the next sections assume such duality, it is important to recognize that there are numerous applications that can work happily without it. These can be characterized as "branching" movies, where the user is asked a specific question at a time when the movie has ground to a halt (remember the Czechoslovakian pavilion at the New York World's Fair). In such instances, given that the filmic material is halted anyway, it is not too disturbing to expect a momentary blanking before the continuation comes up on the screen.

It is in the cases where an applicaiton is a computed assemblage of sequences, discontinuous on the disc, but meant to be viewed continuously, that a two headed system is required. The most interesting filmic consequences arise in this case. One way to look upon the computer element is as modeling the editing process, capable of assembling numerous editions from a large source of material.

1.3.4 Computing capacities

Filmmaking, book publishing, and data processing are ordinarily totally separate industries and expertises. Their confluence into a single medium is cause for lopsided developments and some misunderstanding. Remembering that the initial impetus came from recycling old films, it is not surprising that the computer controls and computer capacities have been considered in an ad hoc fashion, at best.

One approach, probably the most sensible, has been to make the videodisc player into an exceptionally dumb computer peripheral, which goes to whatever track it is told and plays in whatever mode it is told. The sensibility of this approach at this time

is that it makes no effort to second guess the requirements of an application. In addition, it poses no potential redundancy with a growing market of home computers.

But as such, the videodisc is nothing. The filmmaker must presume computing horsepower. As we will see, the filmic material is only a small part of the material, in fact, many applications have already shown it to be the least time consuming to make. Usually, the computer models and database are far more complicated.

We will assume a vast computing resource, capable of accessing digital data from the disc. Suffice it to say that the computer's memory can be filled from the disc at any place in order to control specific sequences as viewer-movie interaction unfolds.

2.0 NEW MOVIE TYPES

The following section outlines four new movie types:

- personalized movies
- conversational movies
- navigational movies
- synthesized movies

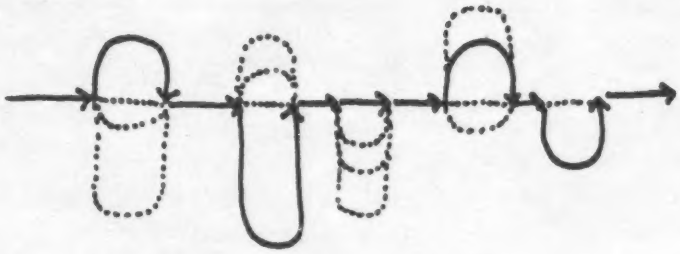
In each case, they are graphically schematized as well as likened to an aspect of computer programming. If you are familiar with computer programming, understanding these film forms will be considerably easier. In part this is because of the algorithmic nature of these new movie types. And in part this is because the movie is not a product as much as a process composed of rules and ingredients.

The dissolution of the editing process is key. In a very real sense the viewer is the editor with the aid of a computer program. User and computer together, in varying divisions of responsibility, perform the functions of cutting and special effects.

In each of the four types, user interaction, to a greater or lesser extent, is required. 5.0 amplifies the nature of the interface. For the present, assume that the user can talk to the system in whatever way you fancy: by pushing buttons or speaking English.

The four types are listed as such for categorical clarity. It is certainly possible, even probable, that an interactive film would have elements of one or more.

2.1 Personalized Movies



A personalized movie can be likened to the process of macro-expansion in computer programming. That is to say, a keyword triggers an elaboration of information, in one form or another. It is in the degree and the form of the elaboration, that we find personalization.

A simple analogy is found in cookbooks. Sophisticated recipes for an advanced audience will include ingredients, preparatory instructions, and some comment like: "cook until done." To the beginner, the latter is totally unintelligible; what we would call an unexpanded macro. Most of us would need time and temperature information. The novice might have to be told to preheat the oven. But, to the professional, "cook until done" is complete and unambiguous.

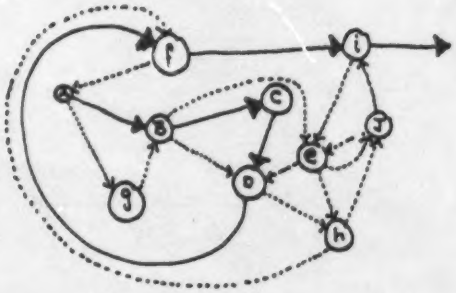
In a similar fashion, one can image scripting a film with similar degrees of elaboration. Degrees of detail and development can be seen in two ways. One, very much in the flavor of the cookbook analogue, is the instructional valve of saying and showing the right amount to a specific person (too much is boring and too little is confusing). The other is driven more by a user's interest where, for example, in a personalized news report

political uprisings in the Third World might be presented in the fullest detail, whereas the surge of gold prises would be glossed over.

The second aspect of personalization is in the form of the elaboration. In technical instruction this is exemplified by the mode of presentation: photograph, drawing, diagram, step-by-step instructions, and the like. The same sequence might exist in both animation and movie image. The one shown would be a function of the cognitive style of the user.

Of the four new types of movie, the personalized movie, seen as macro-expansion, is the least disruptive to traditional film-making processes. The material retains a sequential structure, with beginning, middle and end components to be found as such. It is much like writing a paragraph with IBM, International Business Machines, or largest American computer manufacturer with annual sales...; the elaboration does not necessarily destroy the structure.

2.2 Conversational Movies

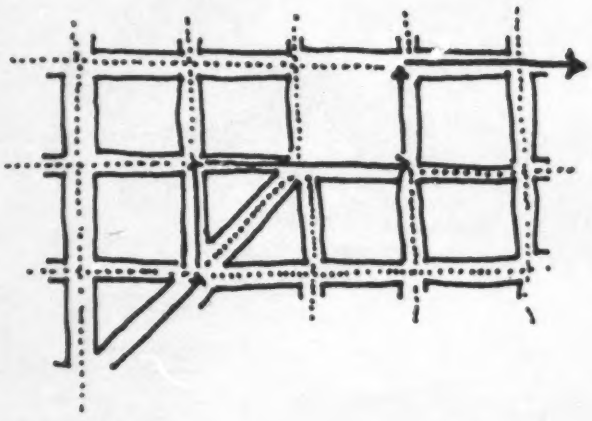


In contrast, a conversational movie has considerably less apriori structure. It can be seen as a directed graph with nodes being un-interruptable scenes. A movie might unfold, passing through several nodes without viewer intervention. Or, it might be strictly composed of retorts.

Consider a conversational movie on flags. The user might wish to traverse the subject in terms of: geography, history, graphic design, or symbolisms. "In 1918, at the suggestion of Samuel C. Reid, the original thirteen stripes were restored to the American flag and Congress voted to add a new star on the 4th of July succeeding the admission of each new state." Such a chunk of material might be presented in the historical development of our own flag, in connection with England's addition of the cross of St. Patrick seventeen years earlier, or as part of an episode on stripes per say.

The example may be alarming. In some measure, filmic nodes need to be very autonomous inasfar as one does not know where the user is coming from or going to. The internal network can be as simple or complex as one wishes to imagine. In the simplest sense, the directed graph is of feasibility; passing from A to C without going through B would be akin to a nonsense phrase in English, either grammatically (filmically) incorrect or topically (conceptually) wrong. A most complicated internal network would have all the epistemological makings of a machine intelligence quite expert on whatever topic. Clearly, reality is somewhere in between.

2.3 Navigational Movies



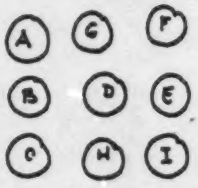
In contrast to a conversational movie, a navigational movie has an external network of controls, upon which information is placed like flesh on bones or buildings in streets. The most specific example is the component of vicarious travel in a recent movie map.

The concept is simple. Film is shot traveling down all streets, in all directions, making all possible turns. Subsequently, the viewer drives the system and the computer stitches together the appropriate scenes to yield a close approximation of "being there."

The feasibility of movement is tied to the reality of a place. Of course one can fantasize in the medium, create fictitious countries, or have a left on Wall Street turn into the Banhofstrasser.

Similar movies can be made for non-geographic material, where one might follow, for example, a model of the human body to reference information about specific organs. What is important is that up-down, North-South, in-out, left-right have an intrinsic, usually spatial, meaning. Consider the hybrid of a family tree, for which up-down is a measure of time in generations, but left-right are very local or have no meaning.

2.4 Synthesized Movies



FILM 1: IBBADF
2: HFBFCCGCFB
3: EIDF
4: IBAFIBAFDCFB

Finally, this would be the hardest new type of movie; it is truly a database only. Once again, the cooking analogue serves well. Imagine sequences composed of stirring, beating, frying; milk, eggs, onions; stored as snippits. If a recipe called for beating six eggs, pouring some milk, etc., the "beat-egg" scene would be repeated six times, followed by a "pour-in-milk" scene, and so on.

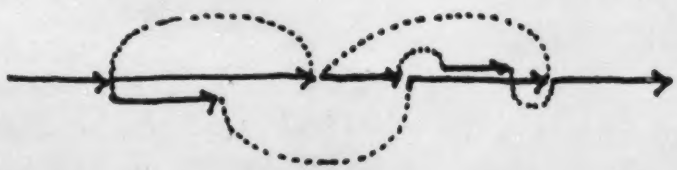
The filmic interstices of such a movie type would be extremely challenging. One is reminded of the 4x4 array of a child's blocks showing the head, chest, waist, and legs each of a mailman, nurse, cowboy and circuslady. From these one can compose a graphically continuous ikon with the head of a cowboy, the fat chest of a circuslady, the small waist of a nurse and the striped pants of a postman.

In the long run, synthesized movies would be part of computer generated material, inclusive of animated sequences derived directly from computer models of reality. Meanwhile, it is a completely new cinematic opportunity to prepare sequences like ingredients and to generate movies like recipes. Note that the same ingredients, mixed in the same manner, but in different order, result in either Floating Islands or a vanilla soufflé.

3.0 NEW FILMIC TECHNIQUES

The following section includes five kinds of innovation or departures from ordinary filmmaking. This list is in no sense exhaustive. It is motivated by two forces. The first is a natural desire to capitalize on the unique opportunities of variable, computer controlled play-back of sound and picture. The second is an exercise in parsimony inasmuch as the video-disc's realestate must be treated as a scarce resource so as to extend playback time where possible.

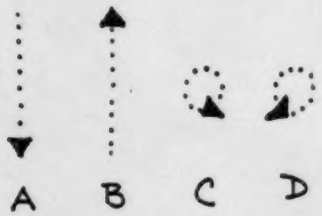
Filmmakers have been known to repeat certain uneventful or difficult to film scenes, sometimes with sound track changes, but unnoticeable, except in poor Westerns. Consider such forsaken techniques as an admirable potential in a new genre of film. A path through the film might look like the following:



3.1 Variable Consecutiveness

The most straightforward variable is frame repetition to achieve slow motion. In a demonstration disc produced by MCA Discovision, this is impressively demonstrated in two scenes: tieing a knot and playing a card trick. Only through speed variations (user controlled) is the sequence of the knot clarified and the slight of hand in the trick revealed. This seemingly innocent kind of viewer interaction already changes the whole nature of the game.

The following diagram includes more dramatic departures:

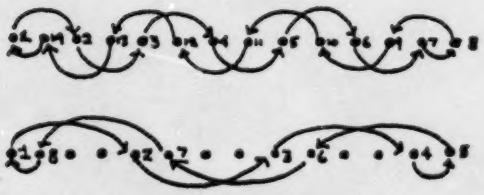


Consider B, playing a sequence backwards, in real time or slow motion. To date this has been a cute stunt where, for example, a scattering of glass on the floor might fly up to the table systematically arranging itself into a bottle. However, there are more cogent applications, where processes are reversable or sufficiently close. For example, tightening and loosening a bolt can be portrayed with the same footage. Much of dressing and undressing is reversable; as are most processes that do not have an intrinsic linear direction with respect to ground.

It is interesting to note that some anomalies are tolerable. A recent example included filming a street out of the back window

of a car. Played backwards, it was an accurate portrayal vis-a-vis the buildings of driving down the street looking out of the front window, except that the other cars and people were moving backwards. Note that if such a sequence were to be used backwards in a film, the camera had best be upside down, which is not the case with variable consecutiveness afforded by the videodisc.

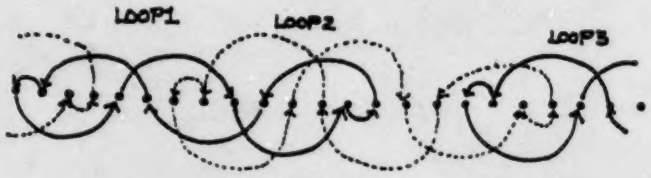
Loops can be endlessly complex nesting of repetitious segments, a short as one step forward and as long as a five minute car ride. A loop is achieved by interspersing frames:



This is necessary because otherwise the videodisc player would arrive at the tail of a sequence and require a blanking period to scan back to the head. It limits fast forward to 2x insofar as most videodiscs (today) cannot scan more than four frames during vertical retrace time.

One can imagine an interminable march composed from a few steps forward or indefatigable stirring derived from one revolution.

Dog fights in Star Wars or Battlestar Gallactica could probably be generated from only a few sequences, especially with intermixing of otherwise discrete loops:



3.2 Motion without Movement

In this subsection we have a great deal to learn from animation techniques. There are new opportunities to play with the phi phenomenon. This idea is to use only a few frames, repeated in planned or random order, to give a sense of motion. On the surface this may offend the filmmaker. However, it deserves serious consideration insofar as it is an enormous saving in disc space and, no matter how much disc space is available, one always seems to need more.

A number of examples have been illustrated with still photographs of flags, waves, and bobbing heads. Properly played back, the scene looks like flags blowing in the wind, waves crashing on the beach, or people nodding and conversing. In some cases, this can be achieved with as few as four frames!

3.3 Sound

The most important consideration for sound is to remember that it can and usually will be disjoint from the picture. Slow motion, reverse, and still frame type of playback, require sound to come from a second disc or head.

Current applications have been limited by available players, so that sound and picture are very much locked together, like an optical track is to film. People have played with stereo, binaural, and multiple languages. Colombo in Japanese is now a classic to the subculture of videodisc enthusiasts. More interesting elaborations might include alternate explications of the same material, a continuous sound track for a two pass loop, or a separate sound track for a different entry to the same material (as illustrated in the beginning of this section).

Binaural sound is a simple but impressive opportunity. In a cinema for one, it is not too demanding to expect the viewer to wear a headset. This allows for an accoustic sense of presence, quite different from stereo. The idea is well known to audio engineers. It requires that the filmmaker record sound from a headset-like device with a microphone lodged in each ear. The result is a faithful reproduction of what you would have heard, inclusive of one's intervening head and ears (helix and antihelix). Sound attains a spatial quality that is uncanny.

Finally, consider that sound need not be real sound, but can be synthesized music or speech. While this may not have a direct consequence on filming techniques, it is an important aspect of playback insofar as most anything (perhaps different for each viewing) can be said. Today's speech synthesizers are either digitized words (Speak & Spell is a sophisticated example) or

assembled phonemes (which invariably sound like the talk of a drunken Swede). Within the margins of lip synchronization, the opportunities are boundless.

3.4 Stills with Sound Over

The still frame can be considered a degenerate sequence. Accompanied by voice over, it is an important technique because of the immense saving in realestate. Consider that the bandwidth of a television picture is 4.5 megahertz, whereas sound is only 20 kilohertz (admittedly it should be more).

The industry has given still-with-sound-over too little attention, to date. Partly this is because of the technical problem of inexpensively grabbing a frame while playing continuous sound. Partly this is due to the conspicuous aversion to the technique, except, perhaps, in titling sequences.

There are minor examples, like holding up a good-bye note of a jilted boyfriend for the audience to read, with or without a sweet voice accompaniment. But they tend to be limited to static presentations of intrinsically static material. The real opportunity may come from the use of static images to portray dynamics. This is particularly valuable in conjunction with computer generated symbols overlaid on the screen, as text, diagrams, or simple graphical highlights.

3.5 Overlays

Enter computer graphics. The increasing commitment to television as the common denominator for computer graphics systems, is resulting in a major body of experience with shape oriented and textured graphics. Simple examples would include dots and arrows indicating particular features in synchronization with a sound track. More dynamic examples could include animated foregrounds as a simulation, abstraction or cartoon of reality.

The authoring station required to achieve this is considerable (but, outside the scope of this paper). Suffice it to say that the filmmaker can include highlights and indicators that overtly call attention to positions or areas on the screen. One can imagine a whole genre of Sesame Street films that homogenize image, text and graphics. Big Bird's lip synch is sufficiently floppy for all sorts of computer-generated letters to fall out of his mouth.

In the near future, overlays can be generated from images themselves. The same technologies that will emerge to grab frames in solid state memory will allow for computer programs to process parts or all of images. Some study is going on in the area of automatic rotoscoping. Image processing type applications may include turning a day scene into night, placing a child's photograph on the head of a cowboy, or altering the color of a dress.

3.6 Post Production

If one considers a future videodisc system as having at least two video sources, combined with a special effects generator of normal broadcast variety, the applications are innumerable. Interpolative zoom would add more.

Wipes, fades, zooms, and all the geometrical inserts would be the vocabulary of programming languages available to the filmmaker. The same background might have numerous inserts, such that all previous diagrams in this paper could be revised to include partial and complete overlaps.

The ramifications of such automated effects is computationally so complicated that it is left here to the imagination of future inventors, prepared to fully automate, hence find algorithms for, the editing process.

4.0 A MOVIE AS COMPUTER PROGRAM AND DATA

So far, movies have been treated as not-necessarily-sequential frames, nonetheless, movie-like. The basic element is an image, images, or sound ordered and mixed under the control of a more or less sophisticated computer program.

Without departing on a treatise of computers, consider the basic element to be a computer program, with images and sound presented as a data-type, only a little different from more common "print" statement for alphanumerics. The purpose of this alternate perspective is not so much to argue for a different conceptual form, but to call serious attention to the information processing component that surfaces as a result of the potential for random access movies.

What happens is that we need a new input, call it an information "track." Previously, filmmakers record sound and picture. Then, in the editing process, the human operator brings knowledge of the topic and of the world at large to bear upon the filtering and editorial processes. But, as soon as you want some or all of this to be automated, you need an accompanying representation of the information itself, both absolute and relative data.

A lesson might be learned from a page in the history of computer aided instruction. After many abortive attempts to outsmart the poor student in a drill and practice scenario, educators looked upon the computer as a learning machine, rather than a teaching machine. The maxim of "the best way to learn something is to teach it" became the cornerstone of exploratory systems that allowed young students to program computers, with the idea that debugging such programs is the closest mechanical surrogate to understanding one's own learning processes.

In the same fashion, maybe the first interactive movies should not be movies as such, not even control structures from any of the five mentioned in Section 2.0. Instead, consider a pool of scenes and sound tracks, with names or addresses (in the programming sense), that can be controlled by a simple language, probably interpretive, preferably recursive. To the knowledge of this author, this has only been done with computer graphics and animation, never for movie material. Results may shed important light on the terrible problems of representation of filmic material in a computer database. The idea would be for users to make their own movies, from given scenes, if only for the fun of it.

5.0 THE USER AND THE INTERFACE

Movies and television are passive. Some argument can be made that the visual presence and surround of a format like IMAX (seven stories high) is so engaging of the user and is so sensorily moving, that the user is an active participant. Perhaps, but not in an informatic sense.

Interactive movies are driven by viewers. The viewer can control the movie explicitly or implicitly, in the case where a computer model is derived from previous interaction. Either way, the system must respond to inputs. A natural assumption, but not so natural interface, is the use of a proverbial keyboard.

The following section will not elaborate upon keyboard driven movies, but look more fancifully at other interfaces, some of which lend themselves to making the user not just an editor, but conceivably a participant in the film.

5.1 Touch Sensitive Displays

A sufficiently large number of technologies are becoming available to make TV screens inexpensively touch sensitive, so as to justify the assumption that a user can point at the screen and the computer-videodisc system can know the co-ordinates. The problem is to map those co-ordinates into a meaningful input for a specific scene.

The most trivial, but hardly irrelevant, application is that of light buttons: frequently a menu of words which when touched trigger a particular command to redirect the film. This could be implemented in a fashion similar to subtitles, with the same

distressing clutter. While it is unsettling to plan on such overlays, it does afford the kind of interaction which is "interruptive" and not simply a retort.

Another application would be for the user to act as steersman, opening particular doors, following particular people or cars, or entering particular buildings. Very much in the spirit of an Advent Calendar, one can imagine branching through an information space of filmic material on anatomy, Paris or bicycle repair. Unlike the text application, specific "ports" must be displayed at specific times, registered with the moving image. Depending on the application, such registration can be anything from hard to impossible.

In a staged show-and-tell, matters can be so arranged as to have sufficiently small overlap of "areas" for active items to be registered with only minor human intervention at the time of authorship. Other scenes may be so complex and dynamic that the user or author must preview the material and track with index finger the motion of, let's say, a specific tool in the hands of a repairman. Subsequently, the tracking would be displayed as a visible, faint, or transparent target which when touched within a certain radius would trigger something like an elaboration on how to use that particular tool.

The most far reaching (read: currently unmanageable) kind of touch sensitive application would be one for which scene analysis would be requried. Simple techniques are available to turn pictures into approximate line drawings, from whic boundaries and identities can be derived. But the recognition of what has been touched by knowing its shape (in two dimensions at a specific time) is wishful, at best.

5.2 Talking and Looking

Two emerging technologies should be considered in the long run: voice recognition and eye-tracking. Each has current day implementation in extremely expensive hardware, outside the reach of institutional applications, certainly the consumer. Nevertheless, one should anticipate being able to talk to a film and to have its unfolding be "gaze contingent."

One can argue that speech recognition and input is primarily a typing substitute and can be approximated until such time as it is inexpensive enough to justify the modest increment in each of usage. However, this in not quite true. It is a little different in the subtle sense of being in the same mode and medium of characters in a film. In this way, there is a sense of participation, considerably enhanced, to the extreme that one can fantasize being in the film itself.

Eye-tracking is similar, but may be less credible. It is obvious that human-to-human discourse is dramatically affected by eye-contact or the lack of it. In computer applications this remains untested. Only the recent emergence of large format displays has raised an inkling of interest in knowing where the viewer is looking. One can imagine looking at a particular protagonist and hearing that person's point of view. Fantasy includes a kind of virtual camera that can be driven by peering, staring, and a vocabulary of eye-movements.

5.3 Modeling the User

This is unquestionably the most critical aspect of the human interface. It is also the most difficult.

In a personalized movie, one can find simple examples: knowing if the person is right or left handed, how many times the person has seen particular aspects, and previous degrees of interaction (perhaps as a measure of understanding). The more complicated aspects of modeling the user lie in the inference-making that results from acquaintanceship. This is a popular topic with this author, but examples are thin in that operational and convincing illustrations are still missing.

Nonetheless, what is important to the new brand of filmmaker is the notion of user familiarity, both within a film and across films, and how that would change the film sequence. In the long run, it is like having a good friend who reads a newspaper, to whom you ask: "was there anything interesting?" The answer is a complicated interaction between that person's model of you and his model of your model of him (!).

6.0 A FUTURE TECHNOLOGICAL STEP

This short concluding section is devoted to a very particular next step. In all the past sections and subsections, technological speculation was based upon existence in some form, even if only at astronomical cost. Here we depart.

The idea is a conceptual break from the frame. The impact of optical videodiscs on filmmaking has been very much the dissolution and emulation of the editing process. The next step chews into filming itself. Namely, how much camera control can a user be given?

The idea is not new to computer graphics. In its earliest conceptions around 1960 people referred to displays as windows on information spaces, real and abstract. The user controlled these windows with pan, zoom, travel, and three axis of rotation. The exemplary system is a flight simulator which displays the most faithful representation of a computer model of a real place for pilots to conduct test landings and take-offs. The issue is a filmic counterpart.

At this writing a number of lenses are under study to allow for 360° shooting. If we postulate a videodisc no longer tied to the screen or the frame, we can envisage some degrees of pan and zoom, in the hands of the user. This final degree of control may introduce real questions in to the minds of some filmmakers as to the artistry left behind. Nevertheless, it should not go unwritten that someday the viewer will have some kind of virtual camera as well as an omniscient and friendly computer to edit.